Accelerator Physics and Commissioning

M. Syphers

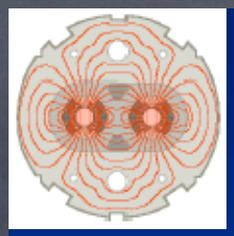
LARP Collab Mtg April 05

Agenda

- Wednesday PM
  - Report from CERN
  - Toohig Fellowship Discussion
  - Commissioning Task Force Discussion
    - Instrumentation Commissioning Discussion
- Thursday AM
  - Hardware and IR Commissioning Discussion
- Thursday PM
  - Accelerator Physics Reports

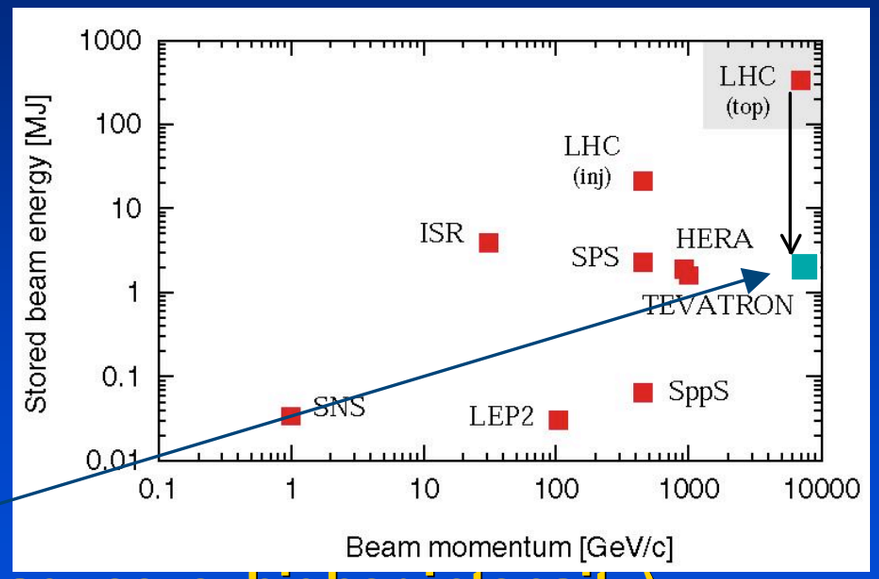
Wed Afternoon

- Reports from CERN
  - R. Bailey, M. Lamont
- Toohig Fellowship Discussion
  - P. Limon
- Commissioning Task Force Discussion
  - V. Shiltsev
- Instrumentation Commissioning Discussion
  - Joint session with Beam Instrumentation



Proposal for early proton running

Phase I collimators and partial beam dump



- **Pilot physics run with few bunches**
  - No parasitic bunch crossings
  - Machine de-bugging no crossing angle
  - 43 bunches, unsqueezed, low intensity
  - Push performance (156 bunches, partial squeeze, higher intensity)
- **75ns operation**
  - Establish multi-bunch operation
  - Relaxed machine parameters (squeeze and crossing angle)
  - Push squeeze and crossing angle
- **25ns operation with Phase I collimators + partial beam dump**
  - Needs scrubbing for higher intensities ($i_b > 3\ 10^{10}$)

Phase II collimators and full beam dump

25ns operation

- Push towards nominal performance

R,Bailey, LARP, April 2005

Accelerator Systems and Responsibilities 1

	System		Equipment Group	Beam Physics or Operational aspects
Systems needed pre beam	Control system			
	Applications software			
	Accelerator technical services	TI operations		
		Electrical supply		
		Cooling & Ventilation		
	Vacuum			
	Cryogenics			
	Access			
	Cold magnets			
	Warm magnets			
	Magnet circuits and power converters			
	Power Interlock System (PIC)			
	Quench Protection and Energy Extraction (QPS)			

We know who these are

No or very few names here

This is the meat of Hardware Commissioning

R,Bailey, LARP, April 2005

Accelerator Systems and Responsibilities 1

	System	Equipment Group	Beam Physics or Operational aspects
Systems needed pre beam	Control system		
	Applications sof		
	Accelerator tec services		
	Vacuum		
	Cryogenics		
	Access		
	Cold magnets		
	Warm magnets		
	Magnet circuits		
	Power Interlock		
	Quench Protecti		

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Accelerator Systems and Responsibilities 2

	System		Equipment Group	Beam Physics or Operational aspects
Systems needed for beam	SPS extraction, transfer, injection and first turn			
	Multi turn losses and BIS dependability			
	Protection devices other than collimators			
	Collimation system and Halo cleaning			
	Clean Beam Extraction			
	Radio protection			
	Beam Instrumentation	Screens		
		BCTs		
		BPM, trajectory & orbit correction		
		BLM		
		PLL for Q, Q', coupling		
		Profile monitors		
		Schottky		
		Luminosity monitors		
	Vacuum conditions during operation and electron cloud			
	Reference magnet system			
	RF systems and longitudinal beam dynamics			
	Transverse feedback			
	Experimental solenoids and compensations			
	Experimental equipment (Roman pots, velo)			

We know who these are

CERN AP interest known here

R,Bailey, LARP, April 2005

Accelerator Systems and Responsibilities 1

	System	Equipment Group	Beam Physics or Operational aspects
Systems needed pre beam	Control system		
	Applications sof		
	Accelerator tec services		
	Vacuum		
	Cryogenics		
	Access		
	Cold magnets		
	Warm magnets		
	Magnet circuits		
	Power Interlock		
	Quench Protecti		

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Accelerator Systems and Responsibilities 2

	System	Equipment Group	Beam Physics or Operational aspects
Systems needed for beam	SPS extraction, t		
	Multi turn losses		
	Protection devic		
	Collimation syste		
	Clean Beam Extr		
	Radio protection		
	Beam Instrument		
	Vacuum conditio		
	Reference magne		
	RF systems and		
	Transverse feedb		
	Experimental sol		
	Experimental equ		

Accelerator Systems and Responsibilities 3

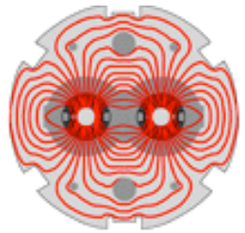
	System	Equipment Group	Beam Physics or Operational aspects
Beam based systems	Beam in the injectors		
	Ion beam in the injectors		
	Orbit feedback system		
	Filling efficiency and flat bottom conditions		
	Ramp and squeeze losses and overall quality		
	Machine protection system		
	Optics		
	Mechanical aperture		
	Machine Impedance and collective instabilities		
	Dynamic aperture		
	Lattice corrector settings		
	Triplet corrector settings		
	Lifetimes		
	Separation schemes		
	Crossing angle schemes		
	Collisions and luminosity steering		
	Experimental conditions		
	Ions		

No or very few names here

CERN AP interest known here

R,Bailey, LARP, April 2005

Toohig Fellowships
in Accelerator Science at the LHC



LARP

The U.S. LHC Accelerator Research Program offers fellowships to recent PhDs in science or engineering to participate in LHC commissioning and other accelerator science and technology efforts relevant to the LHC.

Toohig Fellowships last a minimum of two years, possibly extendible to three, with approximately equal time spent at CERN and a U.S. DOE laboratory, either BNL, FNAL, LBNL, or SLAC.

Send a resume or contact Peter Limon (pjlimon@fnal.gov) or Steve Peggs (peggs@bnl.gov)

Find LARP information at http://www.rhichome.bnl.gov/LARP

Dr. Timothy Toohig, SJ, was a physicist and Jesuit priest who devoted his life to increasing understanding among scientists of all nations and religions.

LARP is a U.S. DOE program, and is an equal opportunity employer

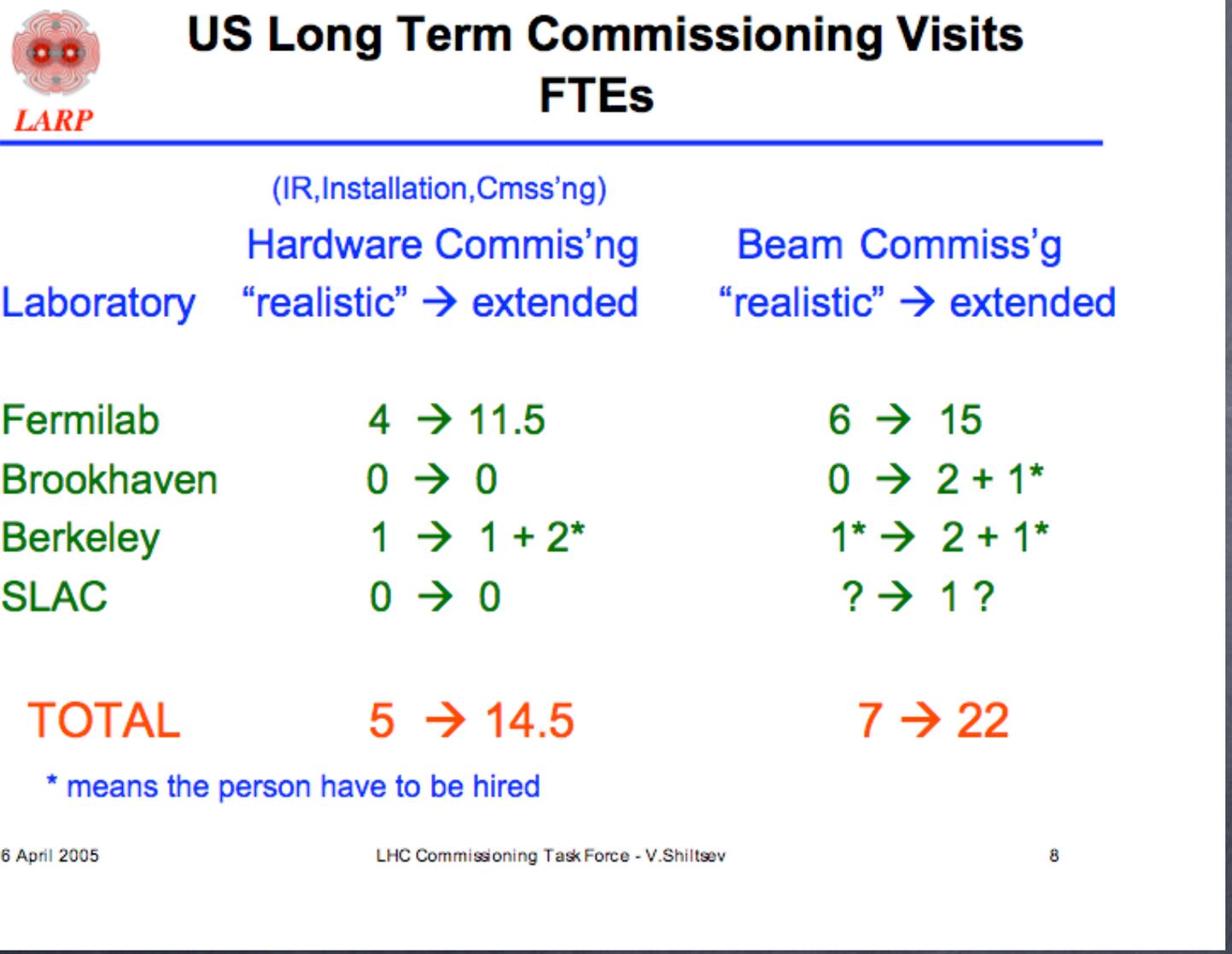
- Discussion led by Peter Limon

Questions & Comments

- Attract bright young people to accelerator science
- Foster international exchange.
  - Visa problems (aaargh!)
- Form committee to select a candidate before end of CY2005. Who on committee? Interviews? Seminar? If so, where? Video?
- How rigid a selection?
- Deadline for poster May 1; Physics Today & Courier WSJ, Le Monde, by June 30; PAC poster/booth?
- Supervision? How? Where? What is the role?
  - Pairing postdoc with senior person
  - Which lab? Related or not to topic?
  - Finding job at end of term
  - Do we select supervisor?
- Salary: straightforward to pay in the US - at CERN ? will they get “Project Assoc Status and extra $$? should they be paid more than “normal” (to attract brightest?)

Commissioning Task Force

--Shiltsev



LARP

US Long Term Commissioning Visits
FTEs

Laboratory	(IR,Installation,Cmss'ng) Hardware Commis'ng "realistic" → extended	Beam Commiss'g "realistic" → extended
Fermilab	4 → 11.5	6 → 15
Brookhaven	0 → 0	0 → 2 + 1*
Berkeley	1 → 1 + 2*	1* → 2 + 1*
SLAC	0 → 0	? → 1 ?
TOTAL	5 → 14.5	7 → 22

* means the person have to be hired

6 April 2005 LHC Commissioning Task Force - V.Shiltsev 8

- Gaining understanding of needs, and of possibilities, including "Project Associates"
- working on listing possible people, tasks
- desire to see "the letter" arrive soon...

Commissioning Task Force

--Shiltsev

LARP

US Long Term Commissioning Visits

	(IR,Installation,Cr	
	Hardware Com	
Laboratory	"realistic" → ex	
Fermilab	4	→ 11
Brookhaven	0	→ 0
Berkeley	1	→ 1
SLAC	0	→ 0
TOTAL	5	→ 1

* means the person have to be hir

LARP

General Conclusions

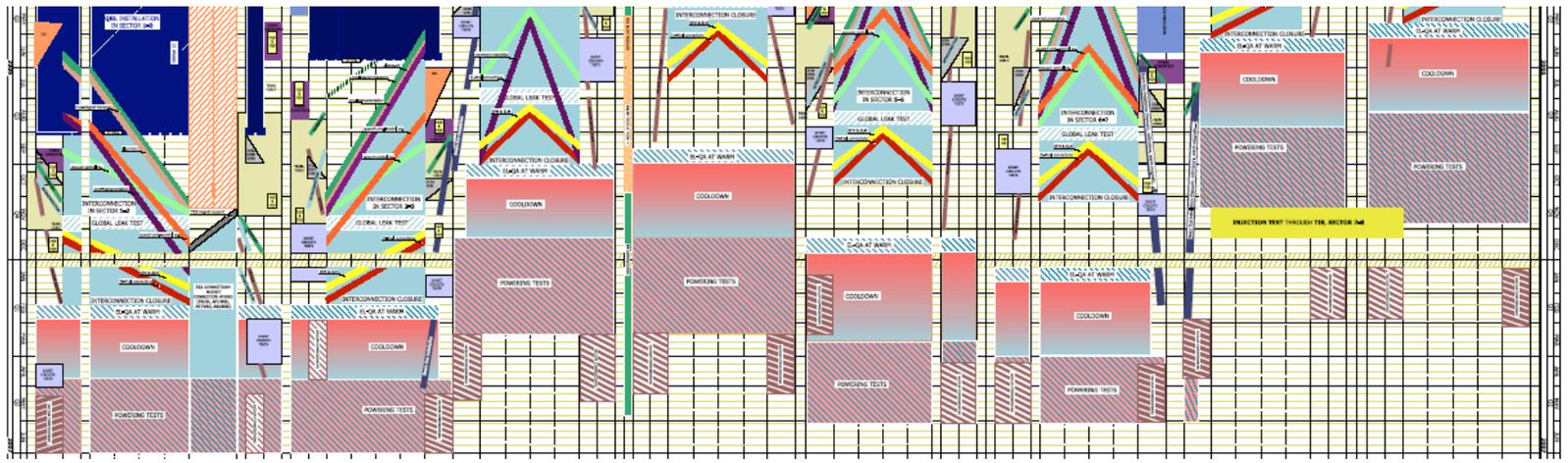
- Recently formed CTF is functioning
- Preliminary investigations show that US labs can provide 1/9 to 1/3 of the man-power missed (and needed) for the LHC installation and hardware commissioning and ½ to 100% of personnel LARP want to employ in the beam commissioning.
- Organization of the US contribution to the LHC commissioning has to be energized, and the CTF is forming recommendations on that subject
- We are in a good shape to present a comprehensive report in July'05

Thu Morning

- Status & Schedule of LHC Hardware Comm. at CERN
  - R. Saban
- DFBX and Absorber commissioning
  - J. Rasson
- Separation Dipole Commissioning
  - P. Wanderer
- Quadrupole Commissioning & IR Above ground Fitup
  - M. Lamm
- Remote Monitoring for Hardware and Beam Commissioning
  - E. Harms
- Discussion: US Hardware commissioning participation

Status and Schedule from CERN (Saban)

- Useful tutorial on reading General Coordination Schedule!



Other issues:

- Discussed in detail HC schedule and plans

a) Short term LSS8 (Winter 2005-6)
b) Sector 7-8 and 8-1 (second half of CY06)
c) Commissioning around remaining “even” IP’s

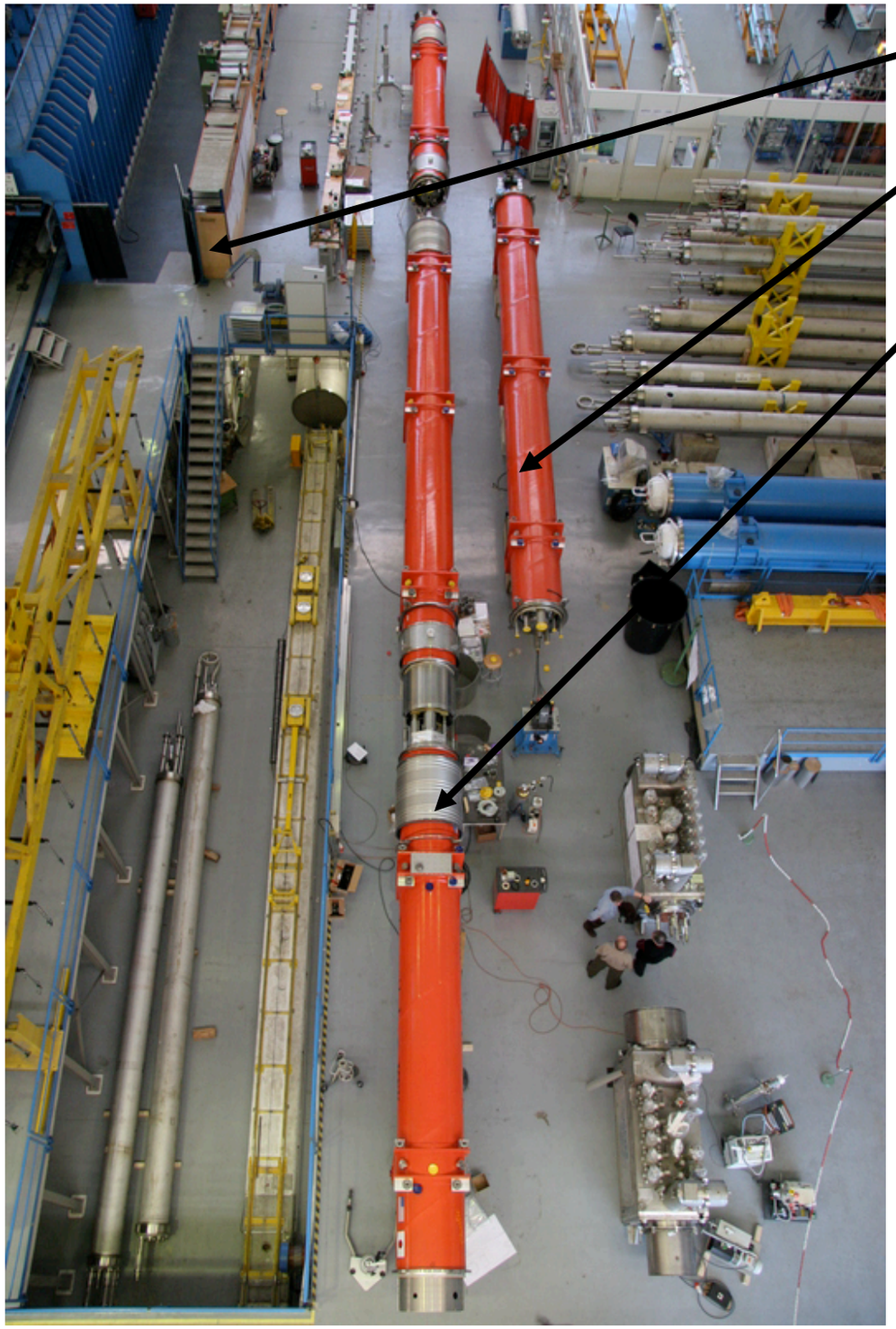
Experience from “a)” and “b)” will guide “c)”

- Discussion of 1-year “Project Associate”
- Identified most needed personnel resources

Installation and HC Activities

- DFBX
  - Busy device which will require some care and feeding even after CERN Delivery
  - Delivery and acceptance going well
- Quadrupoles and plans for IR commissioning
  - Quad deliveries completed by end of CY05
  - Lined up 2 suitbable “long stay” IR commissioners
- BNL Dipoles
  - All complete, most shipped
  - Installation and Commissioning deemed fairly straight forward…
- Remote monitoring
  - Should be very useful tool for monitoring beam line commissioning
  - HC may be better served with Electronic log book and quench data base

LHC Assembly Building March 2004



- Inner Triplet Fitup Ongoing
  - Alignment Tests of Q2 Element
- DFBX Acceptance

- March 14-March 24th
- Participants: Joseph Rasson (LBNL), Phil Pfund, Tom Page, Tom Nicol, Jim Rife, Michael Lamm (FNAL)

  – Q1,Q2, D1 already on magnet stands
  – Q3 acceptane, place on magnet stand
  – Complete Q1-Q2 , Q2-Q3 interconnect
  – Complete DFBX acceptance tests

– April 12-22 Finish Fitup

– May-June Prepare for Installation

Round Table Discussion

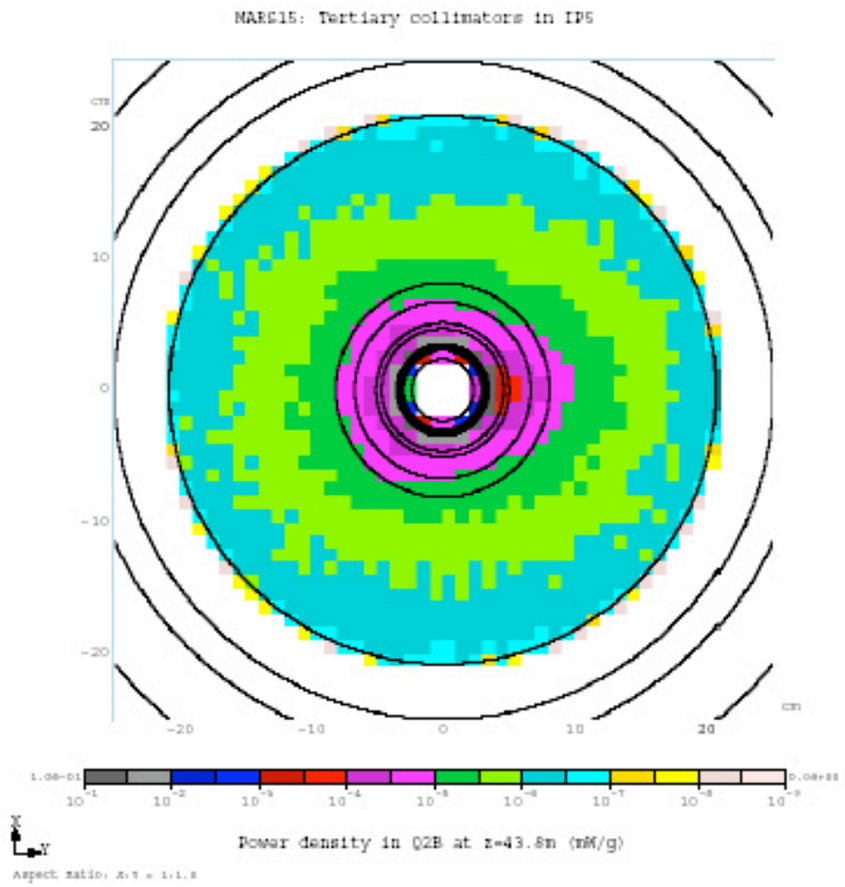
- Very Interesting discussion. For e.g., shared experiences about past hardware commissionings and experiences about living/working at CERN.
- Other discussions centered around the role of the LARP participation in LHC HC. Some of the issues addressed:
  - Where are the ~100 extra people coming from??
  - Not all identified!
  - Teams from Europe and elsewhere, including technicians to perform a specific task
  - US contribution is small in numbers; commissioners would be integrated in CERN groups and HC teams
  - Clarrification and rationale of the Project Associate status
  - Applied to all long-term LARP visitors
  - Importance of getting “the letter” from DG to US lab directors sent ASAP as a starting point for global commissioning

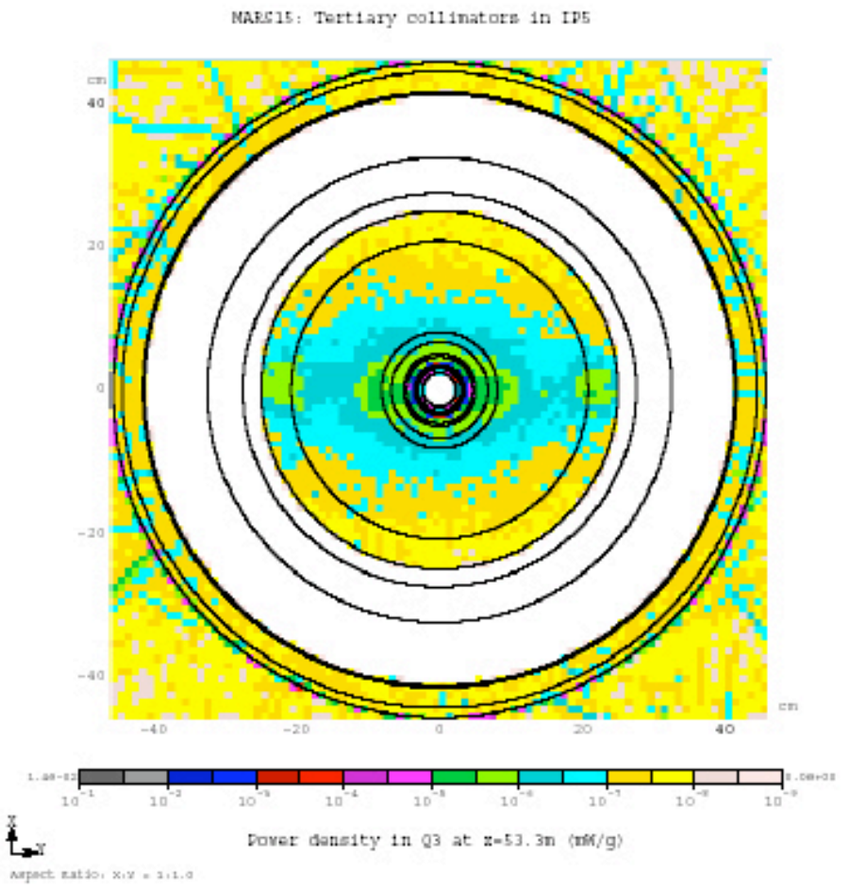
Thu Afternoon

- IR Energy Deposition Status report
  - N. Mokhov
- IR & Beam-Beam Status report
  - T. Sen
- Electron Cloud Status report
  - M. Furman
- 3D Electron Cloud Simulation
  - J-L. Vay

Tertiary collimators appear feasible.

POWER DENSITY IN TRIPLET QUADS





Peak power density of 0.35 mW/g occurs in the Q3 superconducting coils at z = 50 m (β_{max}). Therefore, the maximum "scraping rate" on the TCTV/TCTH couple is about 2×10^6 p/s.

Options for IR upgrade

- Triplet first optics with $\beta^* = 0.25$m
- Dipole first optics with $\beta^* = 0.28$cm
  - Triplet focusing
  - Doublet focusing

Dipoles First - Matching

- Beams in separate focusing channels
- Triplet quads Q1 – Q3 at fixed gradient = 200 T/m, exactly anti-symmetric
- Positions of all magnets kept the same – polarities change w.r.t quadrupoles first optics
- Strengths of quads Q4 to Q10 < 200 T/m
- Trim quad strengths QT10 to QT13 < 150T/m
- Phase advances across IR are different – could be tweaked
- Solution only at collision optics – sufficient for magnet designers

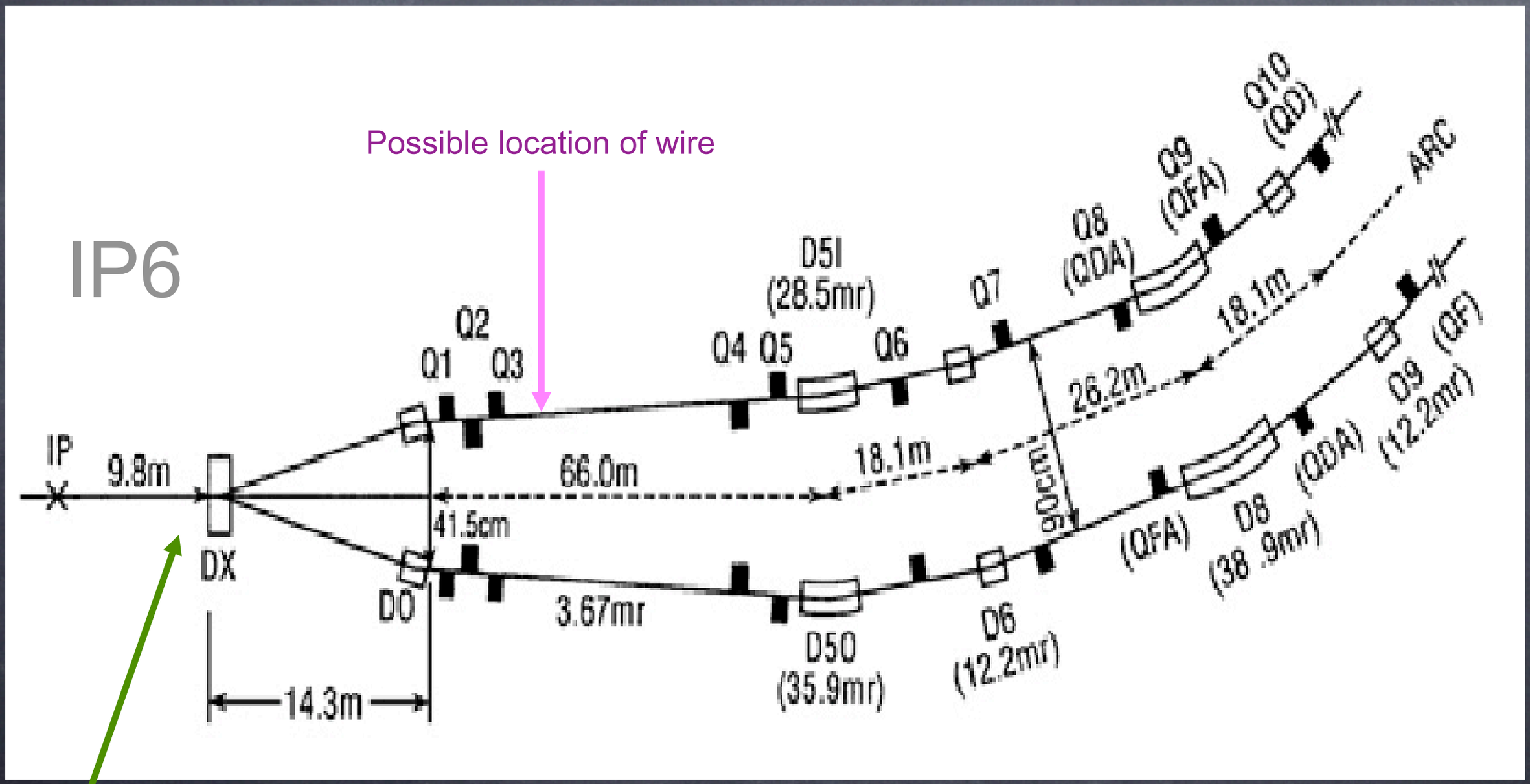
β Maximum in Quads

	Quads first β^{max} [m]	Dipoles first β^{max} [m]
Q1	4538	15100
Q2	9193	23036
Q3	9427	22720
Q4	3323	12517
Q5	1559	8859
Q6	984	2791
Q7	285	748
Q8	261	2857
Q9	270	693
Q10	153	162
QT11	181	185
QT12	183	183
QT13	173	172

Magnet R&D challenges

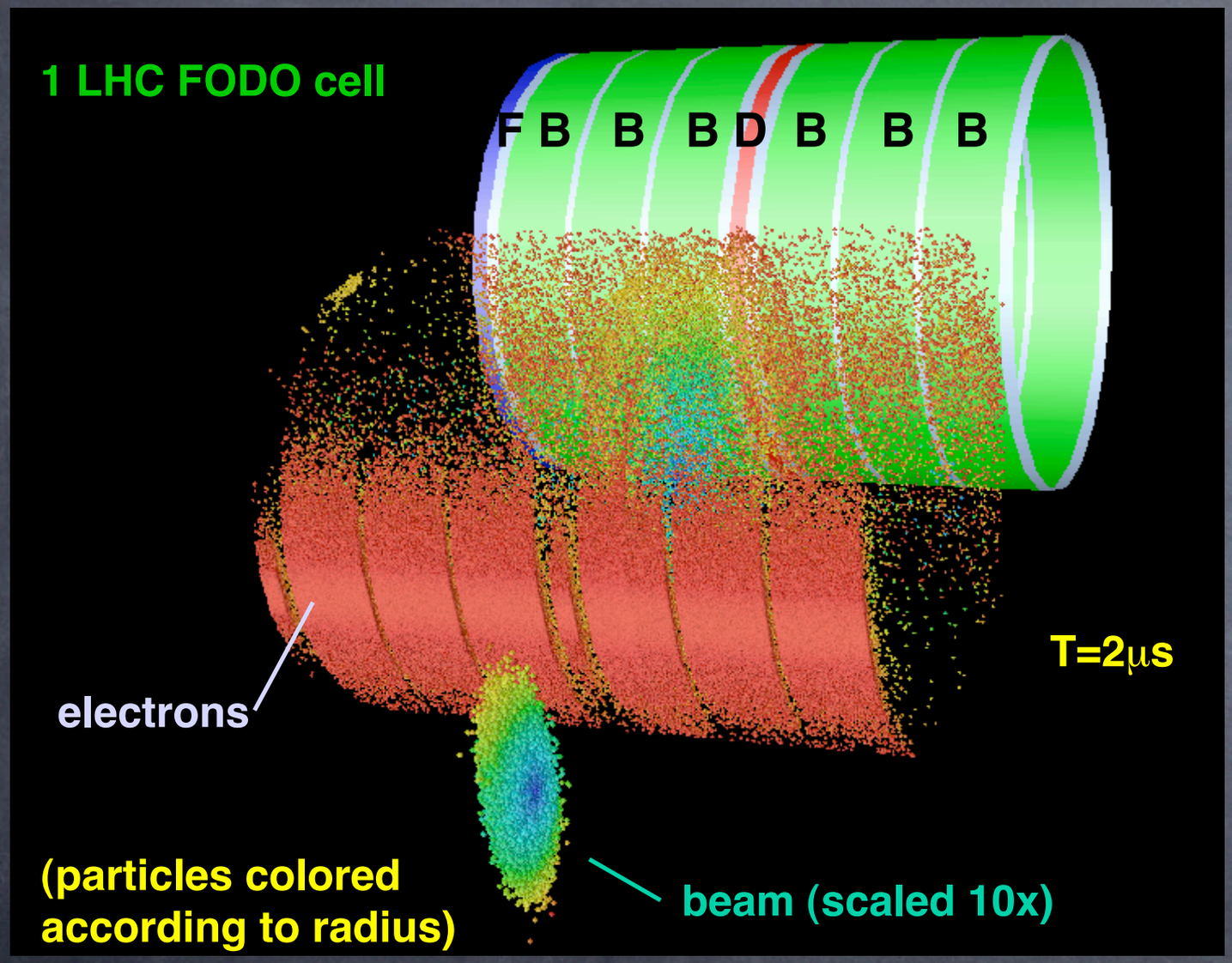
- All designs put a premium on achieving very high field:
  - Maximizes quadrupole aperture for a given gradient.
    Separates the beams quickly in the dipole first IR
    => bring quads as close as possible to the IP.
    Push B_{op} from 8 T -> 13~15 T in dipoles or at pole of quad => Nb_3Sn.
- All designs put a premium on large apertures:
  - Decreasing β* increases β_{max} => quad aperture up to 110 mm?
  - Large beam offset at non-IP end of first dipole.
    => Dipole horizontal aperture >130 mm.
- Energy deposition:
  - quench stability, cooling, radiation hard materials.
  - Nb_3Sn is favored for maximum field and temperature margin, but considerable R&D is required to master this technology.

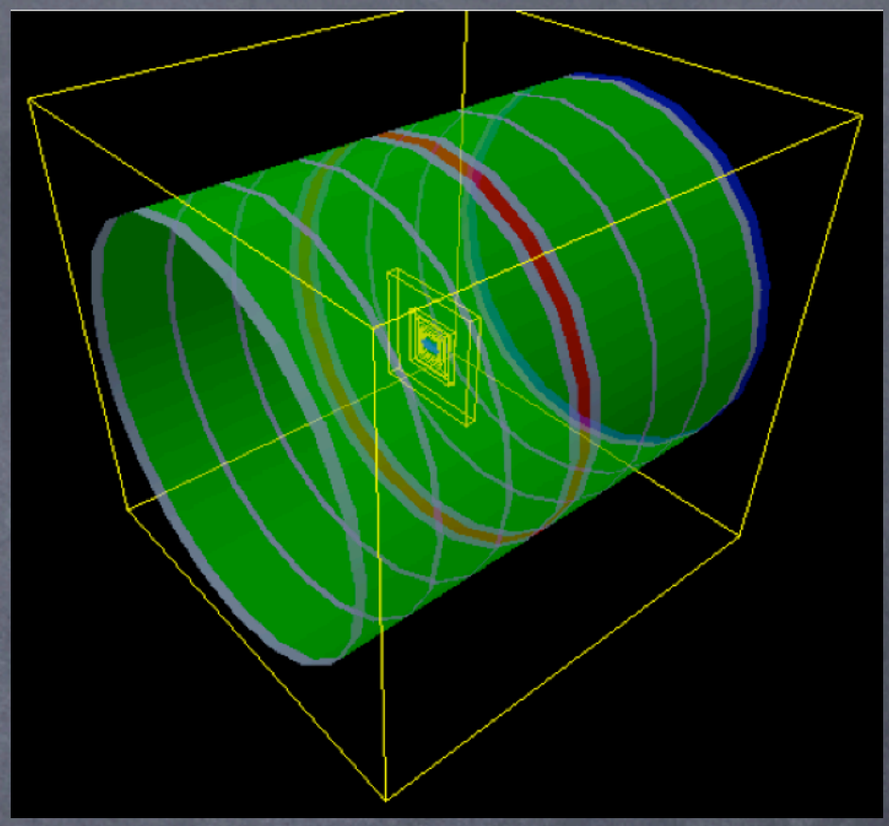
RHIC may test long range beam-beam wire compensator

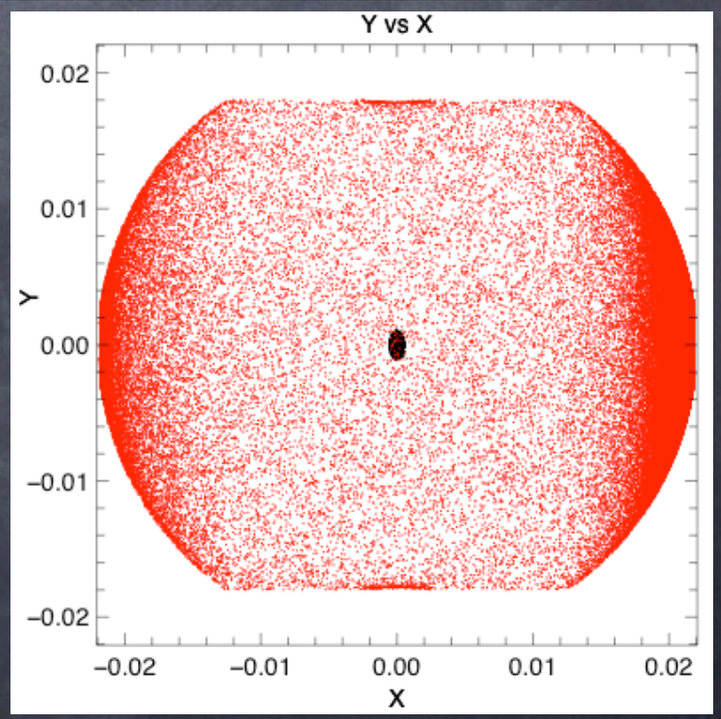


Phase advance from parasitic to wire = 6^{o}

M. Furman, J.-L. Vay: Application of a new 3D e-cloud code (WARP+POSINST) to LHC







- AMR provides speedup of x20,000 on field solve

Movie... (*Jean-Luc Vay*)

Comments/Conclusions

- Most of Session concerned with "commissioning"
- CERN is firming up their commissioning scenario; lists of Task Leaders is shaping up, in progress
  - will begin inserting "real" LARP names …
- Many at meeting appeared "concerned" about financial support for LARP commissioners
  - Project Associate position -- great help
  - Official "letter" will also help push DOE/US labs…
- Master Schedule -- can now interpret (Thanks, Roberto!)
- Making progress toward remote access of LHC data

Comments/Conclusions (cont'd)

- Commissioning Task Force on schedule to provide report, recommendations this summer
- Toohig Fellowships hopefully to be offered this year
  - Possibly more slots than candidates, at first;
  - however, must be "picky" about choices
- Good progress on future IR upgrade design issues
- Continued excellent progress on e-Cloud simulations
- AP-C now in better position to firm up upcoming budget (FTE) requests